minus one tail. You may like to know the spot was about half a mile west of Stampa, beyond the hamlet of Cultura; one found by the rough bridge, and the two just beyond, in clearings of alder scrub. That was a good place too for 'Coppers.' Stampa seems well placed. Promontogno is too hot and shut in, but I should like to hunt earlier in the lovely little Val Bondasca above it. I have come here to look for var. *prorsa*, but it has turned out too wet. I shall probably stay a few days."

Notes on breeding Odontopera bidentata.

By W. BOWATER, Lieut. R.A.M.C.T., F.E.S.

In 1909 I commenced breeding *Odontopera bidentata*, and have continued till the present time. My main object was to discover the method of the heredity of the melanic form of this species. It was found to be Mendelian; the melanic form being a simple dominant. and the type form the recessive. Full details have been recorded.* Since then the experiment has produced still more evidence to confirm this.

I have bred from ova	2300	specimens.
Ditto from larvæ	350	,,
Imagines captured or exchanged ...	700	,,
Total in cabinet	3350	

I have now about 650 pupæ.

During the experiment over 200 pairings have been made, and 71 families have reached maturity. This does not represent the mortality due to disease. Many families were given away, or exchanged, or destroyed.

Copious notes on every detail of the life-history have been made, and may on analysis be found useful for publication at a future date. This specially refers to microscopical details. Throughout the experiment scrupulous care has been taken to keep each family separate, for in the study of heredity this is absolutely essential, a *sine qua non*. Departure from this rule has led at times to some confusion, and apparently conflicting evidence. I would earnestly appeal to all breeders of Lepidoptera to keep families separate, and so labelled that material would be formed from which valuable evidence might be obtained bearing on some of the vexed questions of heredity, especially as to the heredity of *small* characteristics, anatomical, physiological, and even psychological. The following details are observations made on the specimens used in the experiment and on them only.

1. *Pairing.*—This usually occurs soon after emergence, and in several cases even before the wings were quite dry. In some cases, however, 24 hours elapsed before copulation. In three cases fruitful pairing occurred between ♀ s emerged 4-7 days and fresh ♂ s. Copulation almost invariably occurs between 8 p.m. and 11 p.m. The ♀ in almost every case holding on to the lid of the box or cage, and the ♂ hanging pendulous without foothold. Separation occurs in the early hours of the morning. In one case only copulation began at

* 1. *Trans. Brit. Assoc.*, 1913.
2. *Journal of Genetics*, vol. iii., no. 4, April 1914, pp. 299-315.

10 a.m. and ended at 3 p.m. Fruitful pairings have frequently occurred in temperatures of 40°F.-50°F.; and in several cases at 33°F.

2. *Ovulation.*—Unimpregnated ♀ s almost invariably deposit ova 5-12 days after emergence. An impregnated ♀ usually deposits about 100 ova during the night following impregnation, and repeats the process within the next 24 hours. A large chip pill box was used for ovulation, and most ♀ s were satisfied to lay their ova on its sides or lid, but some preferred the small twigs which were always placed in the box. The ♀ s were usually killed as soon as 100 ova were laid, in order to retain them in good condition, but if allowed to live in some cases 400-500 ova were deposited, and in one case 585 were noted. In gauze cages, the gauze was commonly used as a place for oviposition. Glass also often served.

Both sexes accepted moistened lump sugar as refreshment in the intervals of their marital duties.

3. *Ova.*—Pale yellow when laid; if fertile, becoming bronze in 3-8 days, according to temperature. Hatching occurs in 15-34 days, according to temperature. In ordinary April and May weather 22 days. The bronze colour deepens and becomes dusky 36-24 hours before hatching. Ova were kept in glass topped tin boxes. Hatching is usually spread over 2-5 days. Introduction of even a single leaf before hatching is fatal to the ova, presumably this is due to the moisture.

4. *Larvæ on hatching* take no further notice of the egg-shell, but are very active, and walk round ceaselessly till they find a pabulum. Of one batch, which after hatching was forgotten for 72 hours, nearly all were found to be alive. The larvæ were kept in glass topped tin boxes for the first few days, or even few weeks, of their existence. If direct sunlight is prevented from falling on the boxes the mortality is extremely low. Throughout the experiment, of all the larvæ which hatched less than 5% died from disease.

5. *Length of larval life.*—In the single case where forcing was tried, hatching to cocoon formation occupied 41-54 days. Under apparently natural conditions the shortest was May 3rd-June 20th.

Much depends on the foodplant.

6. *Food-plant.*—Privet, especially the evergreen variety, and apple, are the best food-plants. They promote more rapid growth in the larvæ than ivy, pear, plum, sallow, birch, hawthorn, *Prunus pissardii*, willow, poplar, travellers' joy, which also form useful food-plants. Broom produced but very slow growth, but all lived.

7. *Cages.*—In addition to

(*a*) *Ordinary breeding cages*, epecially that special variety which each collector has evolved for his own use, and secretly considers the best on earth.

(*b*) *Biscuit tins*, half-size, were found to be most useful, giving a minimum of trouble, occupying so little space, and cheap, and above all healthy, as might hardly be expected, and, moreover, repeated

experiment proved that larvæ fed up much more rapidly in these tins than in any other form of breeding cage.

The floor of the tin is covered with one inch of moss fibre, *slightly* damp, with a piece of paper on top, leaving a margin, and the twigs of privet or apple laid on top.

Although it is necessary to open them at least every 48 hours, one or two minutes suffices to change the food, and the mortality was not above 3%, including some weak families. Ten to 35 larvæ pupated in each tin, and in many cases mortality was nil, the larvæ being put in when half grown.

(*c*) *Sleeving.*—Ova, or very young larvæ, were sleeved on privet and apple. Mortality less than 2%, except from parasites. As rate of growth in the various families and within a family is so variable, frequent watching is necessary in order to remove full fed larvæ to material suitable for pupation.

8. *Colour of Larvæ.*—It was interesting to note the variation of colour due to environment, as proved in Professor Poulton's classical experiments. The red of *Prunus pissardii* twigs, the beautiful green of apple shoots, the gray brown or black of apple twigs, and the brown of moss fibre, were all faithfully imitated.

9. *Habits of Larvæ.*—They feed only at night, eating voraciously and moving actively. Characteristic "stick" habits by day. Not only a general feeder, but enjoys a mixed diet, or after feeding for weeks on one food-plant readily changes to another. Occasionally cannibalism has been suspected, but never actually observed, and certainly does not occur if food supply is plentiful. It is very probable that various characteristics and habits of larvæ run in families, and efforts have been made to collect evidence on this point.

10. *Pupation.*—Larvæ prefer moss fibre to any thing else in my experience. It should be sieved to remove dust and very fine particles. If cokernut fibre is used many imagines are strangled and fail to emerge from cocoons. Although dead leaves always littered the cage floor, larvæ used them for pupation in only about ten out of over 2500 observed cases.

11. *Cocoon* is made of granules of moss fibre, and is lined by a loose meshed network of strong, thick strands of silk. The cocoons are usually collected in bunches, but I have never found two pupæ in one cocoon. If a larva has no available material for cocoon, it spins a slight net of fine closely meshed silk. If left late in a sleeve, frass is utilised in forming the cocoon.

12. *Pupa.*—Larval skin is shed in 3-5 days after the cocoon is formed. The pupa moves if touched at any time throughout the winter. If kept indoors, even in a non-heated room, emergence of the imago occurs frequently in December, January, and February, especially of the melanic form. In this observation I am supported by several entomological friends. Curiously enough

13. *Forcing* during the autumn does not hasten the emergence.

Pupæ have been kept at 65-78° F. for ten weeks in autumn and they emerged no sooner than the rest of the family left in a cold room.

14. *Emergence* has been repeatedly noted in January and February when the thermometer in the cage stood at 33° F. In one instance only a pupa forced its way half out of its cocoon five days before the imago emerged. Normally dehiscence occurs inside the cocoon. In cases where exit is impossible the ♀ deposits ova in the cocoon.

Emergence almost always occurs between 7 and 11 p.m. Growth of wings occupies 15-20 minutes, and the moths are able to retain their hold on vertical glass.

15. *Habits of imagines.*—During day very sluggish, resting with the wings flat, with the upper hiding the lower, hiding in corners, and if possible touching a leaf, label, or another moth.

In the evening and during the night they rest with wings upright over the back.

Females can be handled with impunity, and lose condition but little if allowed to live a week in cage or pill-box.

16. *Variation.*—When freshly emerged some of the imagines are surprisingly handsome. In the *type* form, variation extends from the palest yellow, buff, orange, fawn, grey, golden brown, up to dark brown with heavier markings.

Within the *melanic* form variation occurs in the intensity, and exact tint of the blackness, and in some cases a large central patch of brown occurs on the forewings, and at times this is sharply defined and quite light in colour.

The melanic form is, however, quite sharply defined from the darkest of the type forms by the fact that in every melanic the abdomen and legs are black, and never is this so in the type. Thus even cripples can be distinguished. The thoracic hairs in the melanic are often lighter than in the type.

A non-entomological eye can distinguish between the two forms in almost every case; and not one of all my specimens could be called intermediate, thus differing from *A. betularia*, *S. lubricipeda*, *A. nebulosa*, etc.

Some specimens are scantily-scaled and these are often rather handsome.

Males are on the average slightly smaller and darker than the corresponding females. This applies to all forms and varieties.

In a "Journal of Variation," I feel that more prominence should be given to this part of the subject, and trust for an opportunity to dilate on this when I see my specimens again.

17. *Gynandromorphism.*—Only one specimen showed signs of this, the left half being apparently ♂, and the right half ♀. I hope to publish microscopical details later.

18. *Inbreeding* was sustained well as shown in diagrams.

19. *Sanitation.*—I am assured that the frequent sterilisation by boiling of cages and boxes and sleeves was essential in this breeding

experiment; and lack of this precaution is a common cause of failure in similar ventures.

20. *Parasites.*—Of these (i.) *Borkhausenia pseudospretella* was the most harmful. In spite of carefully baking the mossfibre used, loss was caused each year by the larvæ of this moth eating the *bidentata* pupæ. The only consolation was afforded by remarkable cases of assembling displayed by the parasite.

(ii.) Four cases of *Ichneumon* appeared.

(iii.) Of the coleoptera a cannibal species slaughtered fifteen larvæ and pupæ in two sleeves.

(iv.) *Earwigs* are under my suspicion, but several prolonged attempts to persuade them when under observation, to devour larvæ or soft pupæ failed.

(v.) *Mice* accounted for 300 pupæ in 1912-13, but fortunately did not break the generations.

21. *Labelling.*—Every cage or box was labelled inside and out. The orthodox method was used; thus :—

10·4 =family derived from the 4th pairing in 1910.
13·34= „ „ „ „ 34th „ „ 1913.
(See diagrams).

22. *Double Brood.*—Family 13·20 consists of about 100 members, which fed as larvæ during May, June, July, 1913, the last to pupate going down on July 31st. Although kept in a cold room, a few imagines emerged in December, and on January 8th. 1914, two emerged and paired. The resultant ova, Family 14·2, were divided into :—

(i.) Batch A, kept in a room at 45°F-55°F. They hatched on February 1st, and the larvæ were incubated at 65°F. They pupated (about 50) from March 12th-28th. Pupæ were forced in a friend's greenhouse and imagines emerged in July. Two paired July 20th and the resultant ova, 15·1, hatched August 10th. My wife, although absolutely inexperienced in entomology, rose to the occasion, and took charge of these (and of all my other specimens) from this date. The larvæ were kept in an ordinary room, fed on apple and privet and about 50 safely pupated September 12th-October 3rd, thus completing the double brood.

(ii.) Batch B ova of 14·2 were left in the cold room. They did not hatch till February 22nd, the temperature then being 44°F. During the next few weeks they lived in 42°F.-53°F. On April 2nd they were sleeved in the garden, survived several nights frosts and pupated out of doors in the first twelve days of May.

Although still left out of doors, some of the imagines appeared in the first three weeks in September. Two emerged October 9th and paired. Resultant ova, 15·2, brought indoors, and kept in a living room. They hatched November 6th, and fed on evergreen privet, pupated in the last week of January and first week of February, 1915.

Thus *bidentata* can with care, be made to withstand various disadvantages of parentage and environment.

23. *Breeding black forms.*—Finally, with regard to the statement

heard at times that the melanic form of *bidentata* does not "breed true," the explanation is that in this species blackness is dominant, not recessive as in *A. grossulariata*.

A recessive character is easy to get pure and "breed true," and a dominant character is difficult. Our domestic sheep forms a good example :—whiteness is recessive, and blackness dominant.

To put it in a practical way for the benefit of those entomologists (probably still numerous) who have not had opportunity or inclination to study Mendelism :—

All Type *bidentata* (whether their parents were both type, one type and one black, or both black) are exactly alike as regards their powers of transmitting colour to their offspring.

Melanic specimens all *look exactly alike*, but really consist of two sorts, differing in powers of transmitting colour :—

A. Pure melanic. (homozygous).
B. Impure melanic. (heterozygous).

Therefore,

1. Type × type always produces offspring all types.
2. Type × melanic produces either
   i. offspring all melanic.
   or ii. offspring 50% melanic, 50% type.
3. Melanic × melanic produces either
   i. offspring all melanic.
   ii. offspring 75% melanic, 25% type.

In 2 i. the melanic parent must have been A.
„ 2 ii. „ „ „ „ „ „ B.
The melanic specimens of families 2 i. and 2 ii. are all B.
In 3 i. although all look alike, there are two possibilities :—
If both parents were A, the offspring are all A.
If one parent was A, and one B, then the offspring are 50% A and 50% B (although they all look alike).

In 3 ii. the parents must have been both B. Of the melanic specimens (75%), $\frac{1}{3}$ are A, and $\frac{2}{3}$ B.

Thus to get a pure black strain is very difficult, because A cannot be distinguished by the eye from B, but attention to the above points will help.

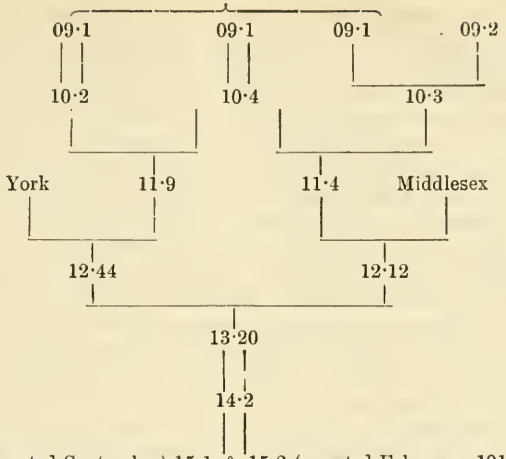
A common experience is as follows :—A black specimen is taken and deposits ova. Larvæ carefully reared, and the following year imagines appear, either 50% or all black. In either case, two blacks are chosen ; paired and larvæ reared. Next year imagines are 75% black and 25% type.

(The type are really pure although parents black, so time spent in breeding from them is wasted).

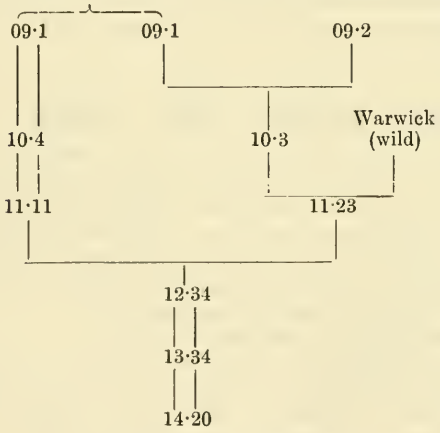
Two black are chosen, and here is the difficulty. There are twice as many B's as A's, so the chances of picking two A's is less than the chance of picking A and B, or two B's, and thus often to the chagrin of the breeder aiming at a "pure," strain, types again appear.

Still, as I have shown, *definite rules govern the heredity of melanism*, and mongrelisation is only apparent not real.

[I wish to acknowledge with thanks the courtesy of Messrs. Mosely of Birmingham, G. T. Porritt, Parkin, and A. Horne, who have given me valuable advice and helped in other ways.]



(Pupated September) 15·1 & 15·2 (pupated February, 1915).



SCIENTIFIC NOTES AND OBSERVATIONS.

Hibernation of Vespa vulgaris.—Having a warm corner in my heart for the British *Vespidae* I was particularly interested in Miss Fison's note on p.87 under the above heading. It is not a rare thing I believe to find queen wasps hibernating behind pictures, but they are usually attached to the *picture*, not to the *wall*. It is not clear how the thread referred to secured the wasp to the wall; if it were in the form of a loop over the thorax or abdomen in the manner of the thread in the case of the pupæ of Pierid and other butterflies, then I should think it was spun by a spider after the wasp had become thoroughly torpid. Since queen wasps fold up their legs and wings beneath the abdomen and thorax and cling to the support only by their jaws, the specimen in question must have gripped a small irregularity in the plaster of the wall by that means, or possibly, a